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EFFECT OF AN OAK FOREST ON A SILTY ACID SOIL - CHANGES IN HUMUS FORM AND EXCHANGEABLE CATIONS

M. Bonneau and J. Ranger

I.N.R.A., Nancy, France

In Center and in West of France, the most important part of the forests are broadleaved forests. Oak is the dominant species. Coppices with standards stands (coppice of oak, birch and hornbeam; stands of oak) cover large areas but one can also find oak high forest, specially in state forest. The sylvicultural trend is the transformation of coppice with standards (C.W.S.) treatment in high forest treatment (either coniferous or oak).

The main type of soils are "sols lessivés à pseudogley"; they are typically polygenic soils with a A_2 horizon developed in a loam layer (some dm deep) overlaying a B horizon developed in a clay layer; this last layer called "argile à silex" is made out of residues of Jurassic and cretaceous limestones; its thickness varies from some decimeters to several meters. The higher clay content of the B horizon is the result of leaching and of heterogeneity in the parent material.

All these soils are strongly acidic and very poor in calcium near the surface. pH of A_2 horizons is lower than 4.5 (in H_2O). Chemical analysis shows that exchangeable calcium is less than 0.5 m.e/100 g of dry matter (it often varies between 0.1 to 0.3 m.e/100 g) and that exchangeable magnesium content is about 0.1 m.e/100 g. The B horizons are richer; their pH vary from 4.5 to 4.8, exchangeable Ca content from 0.5 to 5 m.e and exchangeable Mg content from 1 to 3 m.e.

Under CWS stands humus is a mull or mull-moder form, very rarely a moder one: this is the result of i) litter decomposition enhanced by rather frequent clear cutting of coppice (the rotation varies from 25 to 30 years) and ii) the less regular cover than under HF.

Under HF, one can find humus form of the moder class (going sometimes till dysmoder one); the canopy cover more important, the monospecifity but also the acidity in A_2 horizon are probably the main causes of the unfavorable evolution of humus.

We can think that, in the rural country, inputs of hydrogen and nitrogen from rainfalls, are low and so the strong acidity of the upper layers of soil comes from initial poverty of the parent material coupled with a long action of forest.

We can imagine that transformation of CWS Stands into HF lead to an unfavorable humus evolution. This will induce new losses of exchangeable Ca and Mg and then decrease the soil fertility.

It seems very interesting to study an ecosystem of this country as an example of possible decrease of fertility of a forest soil in a weakly polluted environment under the only effect of change of sylvicultural treatment, the main tree species remaining the same.

A CONCRETE EXAMPLE

Two neighbouring stands of the forest of Marchenoir (West of Orleans), a coppice with standards and an oak high forest situated on a "sol lessivê ã pseudogley" were investigated by two students of the High School of Forestry in Nancy (Slak and Suran, 1982).

Under each stand, the soil has been sampled in 40 points inside a 1 ha area. At each point, three samples were taken off:

a) one sample of known volume (approx. 260 cm^3) taken vertically from the soil surface and including humus (L, F, H layers) and A_1 horizon. After burning in a furnace this sample was extracted with a N $HClO_4$ and K, Ca, Mg were titrated in the solution. The amounts of K, Ca and Mg found in the extract are approximatively the sum of the exchangeable form of the element and its amount included in humus and litter before burning. They are given in grams per sample of constant volume.

b) one sample of unknown volume, taken between 10 and 25 cm deep.

c) one sample taken between 25 - 40 cm.

On samples b) and c) exchangeable K, Ca and Mg were titrated.

Results are given in the table I. All the differences between CWS and HF are statistically significant at 5 % level.

Main trends can be identified as follows:

1. Bulk densities of the samples in the surface layer are lower in HF than in CWS. This is the consequence of a greater organic matter content, following the decreasing rate of litter.

2. A_2 layer is always poorer in exchangeable elements in HF than in the CWS.

3. K, Ca, Mg volumetric contents of surface horizons are lower under HF; thus the low content of the A_2 horizon cannot result from a slower cycle of elements which were taken off by roots in this horizon and accumulated in organic horizons after litter fall.

Two mechanisms can explain the decrease of nutrient content under HF:

a) because of the change of humus form under HF, the drainage water have become more acidic and exchangeable cations have been leached down,

b) nutrient uptake and immobilization in woody parts of the stand could have been greater in HF than in CWS leading to an impoverishment of the intensively rooted A_2 horizon.

These first results have to be considered with some care because of the great difference in the Mg content of the deepest samples between HF and CWS, which may be a consequence of a greater clay content.

Nevertheless, these first data (the evolution of humus form, the significant differences in the nutrients contents of the upper samples of A_2 horizon where texture is very similar) sustain the hypothesis of nutrients losses from the soil when coppice with standards are changed into oak high forest.

We can have here an example of forest ecosystem fragility as a result of a sylvicultural change in the treatment of a same species, without important acid pollution.

RESEARCH PROJECT

The detailed study of this phenomena could be of great interest. Nitrogen cycle and balance should be studied concurrently with those of Ca, K, and Mg as an example of evolution of an organic nitrogen stock when the inputs are low.

The research project could include the following items:

1. Preliminary study of the rainwater chemical composition, in order to verify that hydrogen and nitrogen inputs are weak.
2. Study of nutrient cycle in one (200 years old) or two (200 and 80 years old) oak HF:
   - amounts of nutrients yearly fixed in wood biomass
   - losses in drainage water
   - attempt to estimate elements yearly becoming available from weathering processes
   - estimation of long-term evolution of the nutrient content in the soil upper horizons (between 0 and 60 cm) for exchangeable elements (K, Ca, Mg) and total nitrogen.

3. If it is possible to find a coppice with standards with a soil very comparable to the high forest one, the following points would be added:

   - study of nutrient losses in drainage water under the coppice with standards
   - estimation of nutrients yearly fixed in the perennial biomass
   - study of the modification in microflora and fauna in relation to evolution of the humus layer from mull or mull-moder into moder.

This project would be original because it concerns broadleaved ecosystems on which the influence of acid and nitrogen rich rain-water is of lesser importance than in Northern Europe forests. The nitrogen cycle is probably very different from that of the boreal coniferous forest, and nitrogen nutrition is probably better. As a consequence of the weakness of the inputs, it is not out of the question that the long term nitrogen balance would become negative.

Thus, the suggested study can show a case of fragility of some forest ecosystems only submitted to a traditional sylviculture with only a little change in humus type. The consequence of this fragility could be a decrease of the reserves of exchangeable nutrients and organic nitrogen.

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	Dry weight				Exchangeable Ca				Exchangeable K				Exchangeable Mg			
Sample	Normal		Coppice		Normal		Coppice		Normal		Coppice		Normal		Coppice	
	Av.	S.	Av.	S.	Av.	S.	Av.	S.	Av.	S.	Av.	S.	Av.	S.	Av.	S.
Surface g/sample	176.8	30.1	154.9	36.2	0.059	0.015	0.050	0.015	0.012	0.002	0.010	0.002	0.060	0.011	0.041	0.015
10-25 cm m.e/100g					0.106	0.040	0.079	0.027	0.087	0.030	0.061	0.015	0.156	0.091	0.088	0.029
25-40 cm m.e/100g					0.104	0.040	0.098	0.053	0.103	0.021	0.083	0.026	0.518	0.217	0.~~0~~337	0.264

Table 1. Comparison between soil of a normal stand (State forest of Citeaux) and the soil of a coppice stand (Forest of Marchenoir)